Framework for Selecting Thin-Cake Candle Filter Technology for Removing Solid Contaminant Fines from Recirculating Acid Gas Scrubbing Fluid Streams

Barry A. Perlmutter
President & Managing Director
BHS-Filtration, Inc.
9123-115 Monroe Road
Charlotte, North Carolina, USA 28270

Introduction

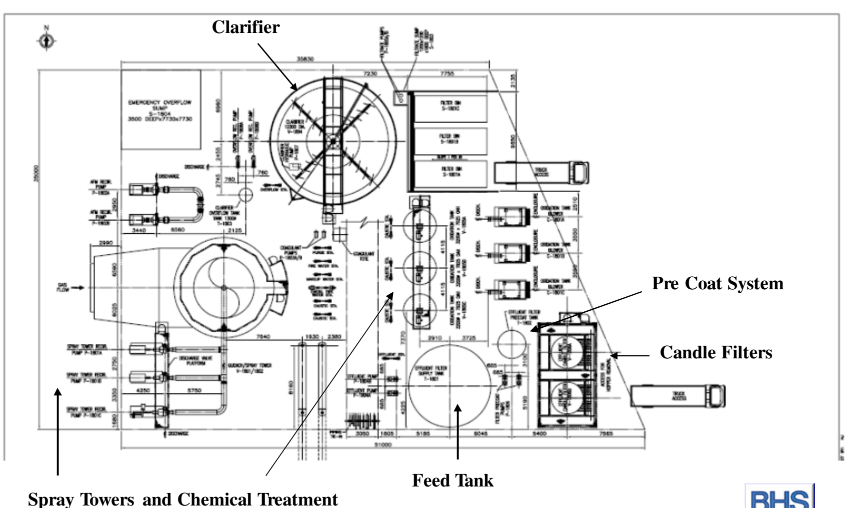
- Recirculating scrubbing fluids are used in many types of applications to remove Sulfur dioxide (SO_2) from a stack gas.
- The flow rate of the scrubbing can be as high as 850 gpm so the fluid must be regenerated and reused to make the process economical.
- Various catalyst and carbonized particles are carried into the gas and are captured by the scrubbing fluid. The fine particles are less than 1 micron and these particles cause fouling and foaming in other equipment.
- The particles must be removed from the scrubbing fluid before it can be reused. It is difficult or impossible to remove particles of this size in settling tanks, hydrocyclones or centrifuges, so the particles must be removed by filtration.
- The use of thin-cake candle filter technology has been proven to be a cost-effective and reliable approach to removing the contaminants

Where Are Scrubbing Systems Found?

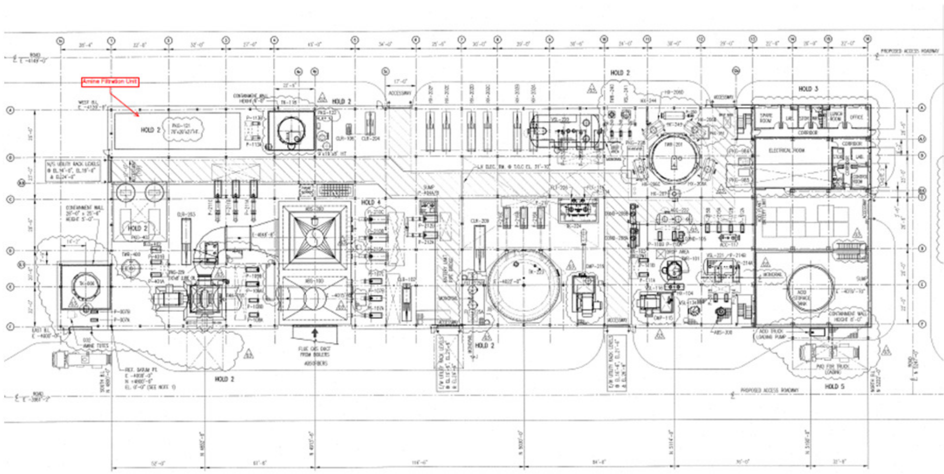
Sulfur Dioxide (SO_2) removal systems use a scrubbing fluid to remove SO_2 from various gas streams. The scrubbing fluids are used to clean gas streams that may come from applications such as:

- Fluid Catalytic Cracking (FCC) and Coker Units at Refineries
- Acid Plant Tail Gas
- Spent Acid Recovery Plants
- Smelters
- Pulp Mills
- Natural Gas
- Power Generation and Cogeneration
- Chemical Process Plants
- Process Vent Streams in Sulfur Plants

Typical Scrubber Process Diagram



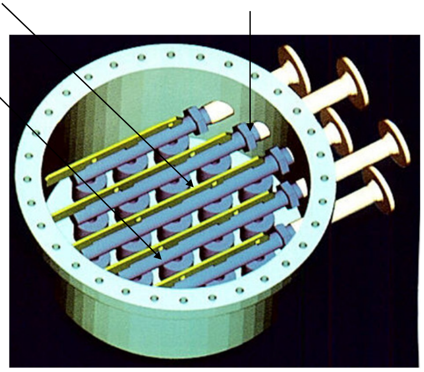
Typical Scrubber Process Diagram



BHS Candle Filter Technology

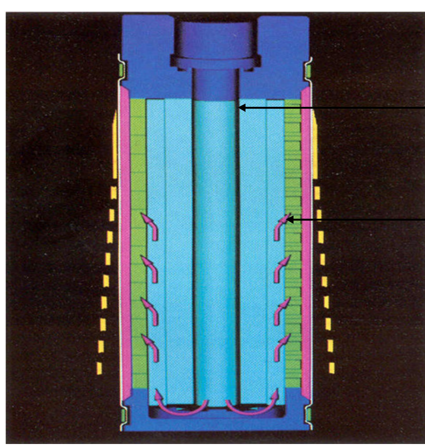
- Registers
- Candles

Vessel Connection



Candles and Registers

Detail of the BHS Candle

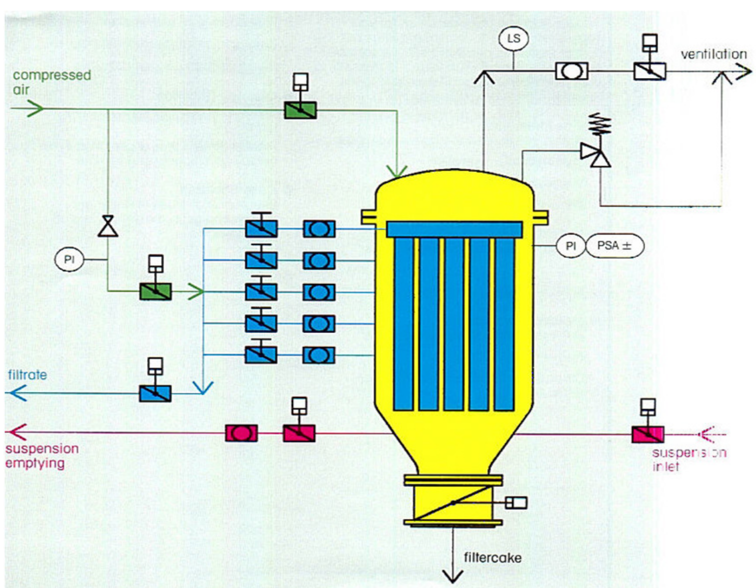


Filtrate Pipe

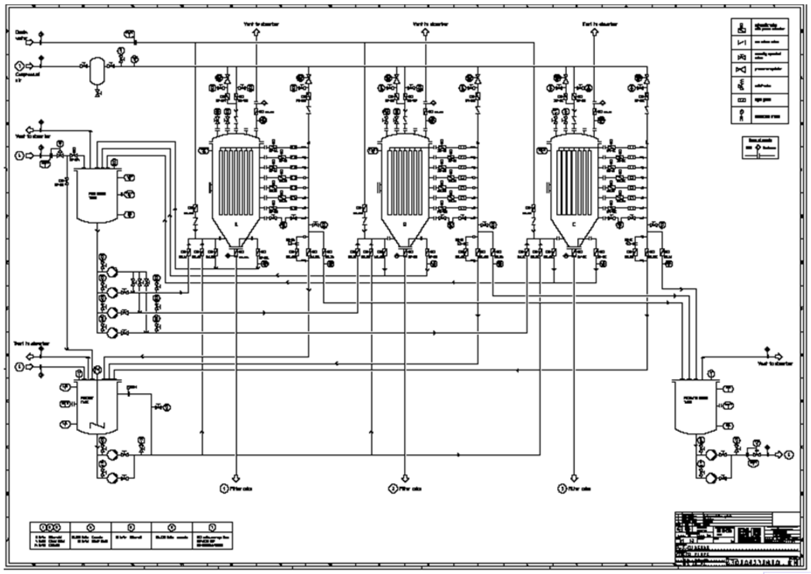
Gas Flow Shown in Purple

BHS Candle – Filter Media Sock

BHS Candle Filter Technology



Typical Candle Filter Process Diagram



BHS FILTRATION

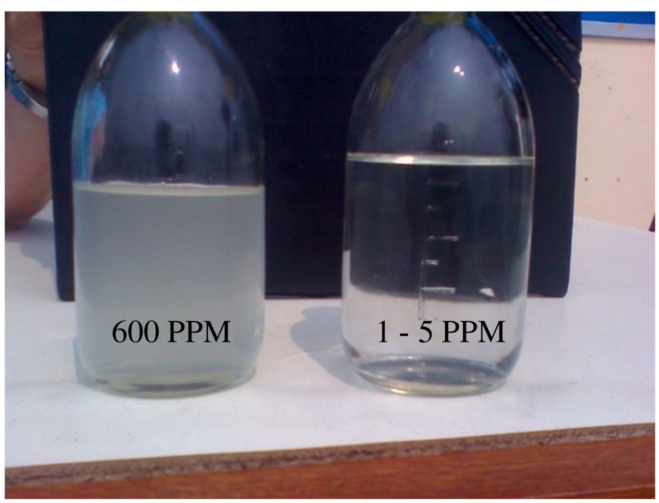
Typical Candle Filter Process Diagram

BHS FILTRATION

Typical Candle Filter Cake Discharge

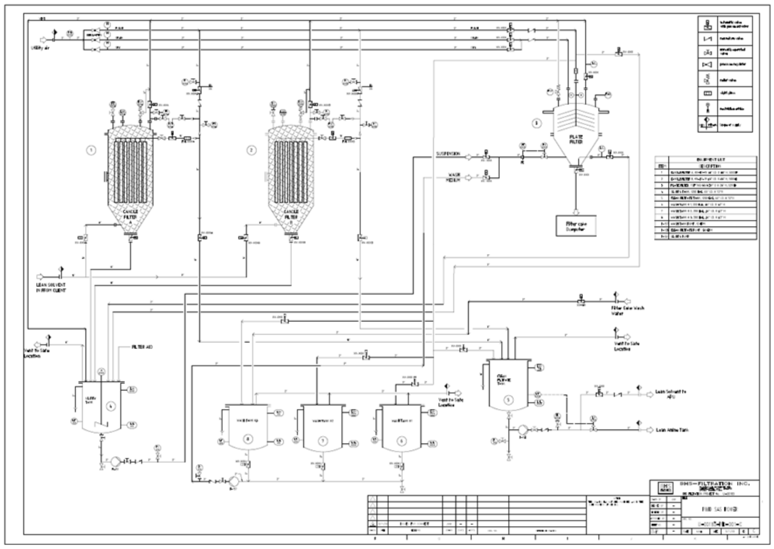
BHS FILTRATION

Typical Candle Filter Filtrate Discharge

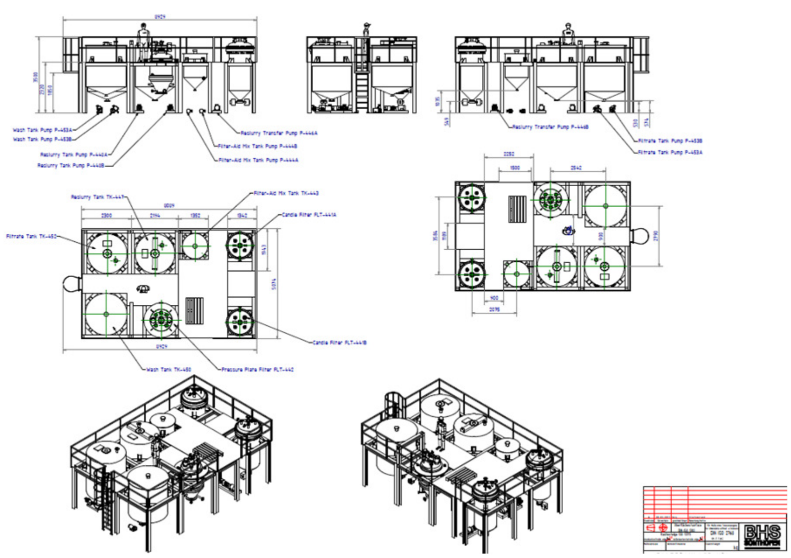


BHS FILTRATION

Typical Candle Filter Process Diagram with Separate Cake Washing and Drying in a Pressure Plate Filter



Typical Candle Filter Process Diagram with Separate Cake Washing and Drying in a Pressure Plate Filter



BHS Candle Filter (2 x 100 m²), Precoat System, Complete Skid, Site Photo

BHS FILTRATION

BHS Candle Filter, Precoat System, Activated Carbon and Polishing Filters, Complete Skid, Shop Photo

BHS FILTRATION

Laboratory Tests

BHS-Pocket Filter

20 cm² filter area

400 ml content

BHS FILTRATION

Laboratory Tests-Filtration

- Filtration and washing tests were conducted in a 400 ml Pocket Leaf Filter that had a filtration area of 20 cm^2 and a fill volume of 400 ml.
- The filter media for all of the tests was a woven, specially designed media for the scrubbing application; the cloth was tested with and without precoat (Hyflo Super Cell).
- Filtration tests were conducted at ambient temperature and at 1.0 bar, 2.0 bar, 3.0 bar and 4.0 bar.

BHS FILTRATION

Laboratory Tests-Washing

Washing Tests

- Cake samples were washed with tap water in a single pass in the Pocket Leaf Filter to determine the amount of washing required to remove the amine salts from the cake.
- It was determined that a washing was efficient enough to wash virtually all of the amine salts from the cake.

BHS FILTRATION

Laboratory Tests-Drying

Drying Tests and Cake Density Measurement

- Five of the washed cake samples were pulse dried in the Pocket Leaf Filter with ambient temperature air.
- The drying was accomplished by pressurizing the Pocket Leaf Filter and then releasing the pressure through the filtrate valve.
- Each sample was dried by pulse drying.
- The moisture of the cake was low enough after drying for easy landfill.

BHS FILTRATION

Scale-up for a Production Filter

A candle filter was selected for this application and was operated using the following processing steps:

- Step 1 = Filling the Filter With Slurry
- Step 2 = Precoating the Filter
- Step 3 = Filtration
- Step 4 = Cake Washing
- Step 5 = Draining the Filter
- Step 6 = Drying the Cake
- Step 7 = Discharging the Cake

Scale-up for a Production Filter, continued

- Each Step requires a certain amount of time and the sum of these times is the total cycle time.
- The minimum size for the filter occurs when the time for the Filtration Step is equal to the sum of the other steps, but it is also desirable for most operating plants to load the precoat into the system no more than one time per day.
- Therefore, the starting point for sizing the system was to determine what size filter would be required to process the required flow rate using a 24 hour Filtration Step.
- The time required for the other steps was then calculated based on the selected filter.

Scale-up for a Production Filter, continued

Required Filtration Area Calculations

Darcy Equation is rearranged to solve for the required filtration area assuming a filtration time of 24 hours, an average filtration pressure of 1 bar and flow rate of 50 m3/hr

Filtration Area = 44.1 m^2

BHS-Filtration Candle Filter: CF 91/46 (91 candles and area of 46.3 m^2)

Two CF 91/46 filters were used in series for this application so that one filter would be in the Filtration Step while the other filter would be in the Washing, Draining, Drying, Discharge, Filling, and Precoating Steps.

Scale-up for a Production Filter, continued

Cake Mass, Volume and Height Predictions

- The cake consists of the precoat, the fines that are collected and the residual moisture in the cake.
- The CF-91/46 has an area of 46.3 m^2 and the lab tests determined that the precoat loading was adequate for this application.
- The fines collected in the Filtration Step can be calculated by the fines concentration in the feed, the feed rate, and the filtration time.
- The fines collected were 600 kg Fines / 10^6 kg Feed X 50 m^3/hr Feed X 1,089 kg/m^3 Feed X 24 hours = 784 kg Fines.
- The total mass of cake (precoat, fines and moisture) per cycle results in a cake thickness of 14 mm.

Scale-up for a Production Filter, continued

Filling Step

The Type CF-91/46 candle filter has a fill volume of 11.0 m^3 and was filled at 50 m^3/hr, so the time for the filling step was predicted to be 11.0 m^3 / 50 m^3/hr = 0.22 hours.

Precoating Step and Required Amount of Precoat

The precoat was pumped through the filter and allowed to recirculate to the precoat tank for 0.75 hours.

Cake Washing

The lab tests determined that the residual amine salts can be removed from the cake. The washing time was = 0.44 hours.

Scale-up for a Production Filter, continued

Draining and Drying

- The heel liquid in the filter was drained by pressurizing the filter with 1.0 bar air while draining the heel through a heel drain valve near the bottom of the filter.
- The heel drain required 0.45 hours.
- The cake was pulse dried in the filter by pressurizing the filter with plant air and then releasing the pressure through the filtrate valves. The drying time required is 0.25 hours.

Cake Discharge

- The cake is discharged from the candles by pulsing air back through the candles while the bottom valve is open. The total discharge time is 0.08 hours

Actual Production Filter Results vs. Predicted Results

- The actual cycle time for the production filters was recorded and found to be within 2% of the predicted cycle time.
- The residual salts in the filter cake from the production filter were undetectable and the residual moisture in the filter cake was suitable for sending to a landfill.
- The excellent fit of the production data to the lab data confirms that the assumptions of a negligible media and precoat resistance, and an incompressible cake are correct.

Summary

- Various fine particles must be removed from scrubbing fluids to ensure proper operation of the scrubber, heat exchangers, etc.
- Laboratory tests were conducted on an amine and the results of the laboratory tests were used to scale-up to a production candle filter that would remove 600 ppm of solids from a 50 m^3/hr amine stream.
- The results in the production filter matched the predictions and demonstrated that candle filter technology is well suited to remove fines from scrubbing fluids.